REMARKS/ARGUMENTS

The Examiner objected to claim 15 for omitting a period at the end of the claim. This informality has been corrected.

The Examiner rejected claims 1, 2, 4 to 8 and 15 under 35 USC 102(b) as being anticipated by German Patent of Winnacher (DE 19627719). Reconsideration is requested having regard to the following comments and submissions. An English translation of the reference has been prepared and a copy is enclosed for the Examiner's convenience.

While it is appreciated that Winnacher pertains to a bore-hole measuring device that contains a device to transmit measured data to the surface, the Figures presented in this reference, as well as the accompanying discussion, do not specifically show the present invention as currently claimed. The cited reference clearly teaches an assembly in which a hydro-mechanical signal producer 4, which consists of a stator housing 5 and a rotary housing 6, is attached to a guide housing 10 which serves to affix the measurement apparatus in a fixed position. The guide housing 10, which is positioned downstream of the signal producer 4, comprises two resilient detents 36 which serve to secure the guidance housing 10 in position. During installation, the measurement apparatus 1, which comprises the signal producer 4, is lowered until the guide housing 10 with its collar 37 rests on the step 31 of the bypass ring 29. Upon reaching this condition, the detents 36 are radially snapped outwardly, whereby with their free ends they grasp the bypass ring 29 from beneath the thereby hold the measurement apparatus 1 securely in its packaging. Clearly, the measurement device 1, in particular the guide housing 10 provides the retaining function by engaging the bypass ring.

In contrast, the movable portion in the present invention, namely the mud pulse generator 16, does not actively engage the landing sub body, but is rather maintained in position by the mechanical action of separate retainer 14. By maintaining the retaining function in the retainer 14, the removable mud pulse generator 16 is simplified in construction, thereby reducing cost, as well as the likelihood of binding upon insertion and removal from the drill string. In the cited

reference, it is foreseeable that the detents could bind either the drill string itself, or debris contained therein upon removal, thus obviating the advantages of having this device removable.

In addition, the present invention clearly requires the retainer 14 to engage the mud pulse generator 16 at or upstream of the outlet end. In the cited reference, the action of the detents to retain the measurement apparatus in position is clearly downstream of the signal producing portion of the apparatus. Thus, the reference lacks the feature of claim 1 the "said retainer engaging said mud pulse generator at or upstream of said outlet end". This is in contrast to the resilient detents 36 in the reference being located downstream of a signal transmitter 4.

In claim 1, the retainer, the mud pulse generator and its outlet end are arranged so as to protect the retainer from turbulent an abrasive mud flow, as described in detail on page 11, lines 7 to 21.

Accordingly, it is submitted that claims 1, 2, 4 to 8 and 15 are not anticipated by the prior art and hence the rejection of these claims under 35 USC 102(b) as being anticipated by Winnacher should be withdrawn.

The Examiner rejected claims 12 and 13 under 35 USC 103(a) as being unpatentable over Winnacher in view of Jeter (US 4,120,093). Reconsideration is requested having regard to the following comments and submissions.

While it can be appreciated that Jeter discloses a pulse generator, this reference does not address the deficiencies noted above with regards to the primary cited reference. As such, it is respectfully submitted that the combination of these two references is insufficient to render the claims in question obvious.

Accordingly, it is submitted that claims 12 and 13 are patentable over the applied prior art and hence the rejection of claims 12 and 13 under 35 USC 103(a) as being unpatentable over Winnacher in view of Jeter should be withdrawn.

The indication that claims 3, 9 to 11 and 14 are directed to patentable subject matter is much appreciated. However, for the reasons advanced above, it is submitted the remaining claims also are in an allowable form.

It is believed that this application is now in condition for allowance and early and favorable consideration and allowance are respectfully solicited.

Respectfully submitted,

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Translation of German Patent DE 196 27 719-A1

Description

The invention pertains to a bore-hole measuring apparatus containing a device to transmit measured data collected in drilling fluids during the drilling in a bore-hole to the surface, with a strung-out housing which is lowerable to a specific position inside a borestring, which is there fixable to a predetermined angle and can then be removed out of the borestring again, a hydro-mechanical signal producer which is placed inside the housing with a stator secured to the housing, which at least contains a passage that drilling fluids can be passed through to a current upstream of the stator and a current downstream side, and an adjacent rotor near to the stator that can be rotated along its longitudinal axis which is located in the housing, which has at least one continuous opening that corresponds to the passage of the stator which can either be turned to a passage position, in which the drilling fluids can flow through the passage and pass the opening aligned therewith, or can be turned to a throttle position at which a closed portion of the rotor slows down the flow through the passage of the stator, and a motor with which the rotor changes the signals of the transmitted measured data in accordance with controlled intervals repeatedly from the throughput configuration, to a throttle position, and again to the throughput configuration, in order to obtain from the drilling fluid a series of coded pressure impulses which correspond to the signals.

An apparatus of the described type is mainly used in the area of directional boring techniques, in order to transmit measured data collected in the borestring from measuring devices to the surface, and to influence the drilling continuation and drilling direction in the required way.

In an apparatus of the described type referred to as DE 41 26 249-A1 the hydro-mechanical signal producer is placed at the upper end of the housing. The stator of the signal producer shows cylindrical drilling on both sides of a disc-shaped rotor parallel to the axis of the housing which constitutes the passage for the drilling fluids. The drilling

circulation flows downstream of the rotor into radial outwardly positioned outlet bores in the mantel surface of the housing. The known apparatus has been established in its practical use. However, it has become apparent that the solid particles carried with the drilling fluids under the influence of the speed of the current and the change of the flow direction due to the required slope of the exit bore lead to washouts in the drilling. which limit the standing time of the stator. A further disadvantage of the known apparatus is that the cross section of the openings in the stator and the openings of the rotor which is required for sufficient amplitude of the pressure impulse limits the obtainable outer diameter of the housing downward and is against a desired further reduction of the outer diameter of the housing. Furthermore, another problem of the known apparatus is that the total length of the measuring probe varies according to the number and type of the connected measuring devices. The measuring probe in the borestring is fixed at its lower end and therefore different positions of the signal generator located at the upper end of the probe are assumed by different total lengths of the measuring probe. It is required to adjust the position of the bypass ring that surrounds the signal generator in the borestring accordingly and thus the effort to set up is increased.

Furthermore, an apparatus as per US 33 09 656 is known for bore-hole measuring while drilling and transmitting measuring data which is carried with the drilling fluids through the generation of continuous, sound waves with modulated frequencies. The known apparatus is firmly built into the borestring and shows at its upper end a signal generator which produces the sound waves which consists of a stator housing containing longitudinal slots and a rotor which is in a rotatable position inside the stator housing, whereby the rotor in its mantel surface shows upwardly open longitudinal notches the lower ends of which are in a throughput configuration and are opposite to the longitudinal slots so that the drilling fluids that enter from the top into the longitudinal notches of the rotor can exit through the lower end of the longitudinal notches through the longitudinal slots of the stator. During the circulation of the rotor the longitudinal notches are closed periodically by the wall portions of the stator which are positioned between the longitudinal slots whereby in accordance with the circulation speed of the rotor, sound waves of varying frequencies are being generated. This known signal generator also

requires a specific flow-rate volume by the signal generator for a sufficient intensity of the produced signal which restricts the entire cross section of the longitudinal notches of the rotor and hence limits the size of the diameter of the rotor at its lower end. Hence washouts occur also at the lower end of the longitudinal notches due to the redirection of the flow of the drilling fluids which pose a disadvantage for the standing time of the rotor.

The object of the invention consists in the manufacture of a bore-hole measuring apparatus of the described type which consists of a small outside diameter of the housing and in comparison to this consists of a large flow-rate volume of the signal generator. A further object of the invention consists in preventing abrasions and elution by appropriate configuration of the circulation flow paths and hence increasing the standing time particularly for the components of the signal generator. Finally, an object of the invention is to eliminate the need to adjust the borestring to varying lengths of the housing.

According to the invention, this problem is solved in that the signal generator is placed in the lower end of the housing whereby the stator is formed by a cylindrical stator housing and the rotor is formed by a cylindrical rotor housing in a bore of the stator housing, arranged coaxial thereto, and both the stator housing and the rotor housing each contain at least a pair of diametrically opposed longitudinally placed slots which form the passage and respectively the opening and through which in the throughput configuration the drilling fluids being fed on the outside of the stator housing can flow into the hole of the downwardly open rotor housing.

With the measuring apparatus as per the invention the passages which form the cross section are created in the stator and the openings in the rotor are created by slots in the wall of cylindrical housings. Thereby the length of the slots can vary in their longitudinal direction without influencing the behavior of the signal generator. This method enables an estimated calculation of the cross section of the signal generator in relation to its diameter and the making of further adjustments to its required needs.

The apparatus according to the invention can be used in borestrings with both a large and small calibration. The positioning of the signal generator at the lower end of the housing of the apparatus enablcs it further that the stream towards the signal generator is from the outside and that the waste stream in the center can be directed downwards without further redirection. The positioning of the slots causes thereby that the drilling fluids in the throughput configuration enter in a stream which flows radial inwardly into the hole of the rotor housing entering at angles from opposite directions and deflecting cach othcr thereby. This method avoids abrasion both on the stator housing as well as on the rotor housing, and thereby enables a long standing time for these components. A further advantage of the positioning of the signal generator at the lower end of the housing is that the signal generator can be used independently of the length of the housing as per the measuring equipment, independently of the composition of the borestring and the bypass ring as provided for in the borestring and can be fixed there. The adjustment measures which are common since then can be omitted. The positioning further provides a simplification in the construction by a guide housing affixed to the lower end of the stator housing which has in its mantel surface a recess cooperating with an orientation wedge and a pawl that can be unlocked in order to latch in the borestring. The drilling of the guide housing is followed immediately by the drilling of the rotor housing so that an unopposed waste flow from the signal generator is warranted.

Furthermore, according to thc invention thc dcsign of the signal generator has the advantage that the bearing of the rotor housing is not subjected to any significant stress. The radial forces in a throttle position acting on the rotor housing are balanced due to the symmetrical positioning of the slots. In an axial direction there are no significant forces being generated since the compression pressure at the nose surface of the rotor housing for thc most part stays the same. Storing the rotor housing with considerable effort can therefore be spared. According to the invention it has rather proven advantageous to store the rotor housing with its open end directly in the stator housing and with its closed end on a drive shaft which is connected to the rotor housing by a torque proof step coupling. The positioning of the rotor housing in an axial direction can take place

immediately at the nose surfaces of the components attached to the stator housing. The basic storing of the rotor housing moreover enables an easy replacement of the components of the signal generators subjected to wearout, namely the rotor housing, the stator housing and possibly the guide housing. According to the invention the exchangeability can be achieved simply by the stator housing showing at both ends of the case drilling an internal thread, where one end is screwed onto the housing section forming the bearing housing of the drive shaft, and its other end is screwed onto the end of the guide housing which is provided with an external thread. It is sufficient to loosen the two thread connections at the end of the stator housing in order to replace rotor housing and stator housing.

In order to prevent the rotor housing being blocked by larger solid particles which are contained in the drilling fluids according to a further claim of the invention, the slots in the rotor housing have a larger breadth than the slots in the stator housing. Additionally, it may be provided that the breadth of the slots both in the stator housing and in the rotor housing increase slightly in the flow direction. This ensures that solid particles that can pass the slots in the stator housing will not get stuck there and will also pass the slots in the rotor housing and will not affect the rotatability of the rotor housing. In order to take up larger solid particles, which are held back by the slots of the stator housing, according to the invention an annular space can be created in the borestring which extends to the lower end of the stator housing. Solid particles which pass the slots can exit unopposed from the downwardly open waste conduit which was formed through the drilling of the rotor housing and guide housing.

The drive of the rotor housing happens preferably by means of a rotational motor that is changeable in terms of its direction of rotation, as described in DE 41 26 249-A1. The signal generator according to the invention can also be used with an advantage in connection with other, for example continuously rotating drives and therewith appropriate controls for producing a signal.

The invention is further explained in the following in connection with an example embodiment which is shown in the illustration. It shows

In Fig. 1 a longitudinal section through a section of a borestring arranged therewith with a signal generator and thc lower end portion containing its drive according to the invention of a bore-hole measuring apparatus,

In Fig. 2 a longitudinal section of the bore string and the measuring apparatus with a further section continuing on from the section as per Fig. 1, and

In Fig. 3 an enlarged illustrated cross section through the signal generator on the level as described in line A-B in Fig. 1.

The bore-hole measuring apparatus 1 only partly shown in the drawing incorporates a housing 2 consisting of a plurality of housing portions screwed onc into the other, the housing 2 taking the form of an elongate, cylindrical post, in which the individual components are located, such as a measuring device, a measurement converter, a signal gcncrator, a signal producer, and an energy storage. In Figs. 1 and 2, only the lower end region of the measurement device 1 is visible, the latter supporting the signal provider and the drive therefor.

The housing 2 has, at its upper end which is not illustrated, a hook to which the housing can bc attached by way of a gripper, and can be supported, and to a cable in a bored section 3, moved to the illustrated end position, or if necessary withdrawn therefrom. The outer diameter of the housing tube is smaller than the inner diameter of the bored pipe of the borestring 3, so that between the housing 2 and the wall of the drill pipe there remains an annular space through which the drill circulation pumped through the section reaches thc cutting edge of the bit. With the help of a guide bearing the housing 2 is centered in the drill pipe.

The end section of the measuring device illustrated in Fig. 1 includes a hydro-mechanical signal producer 4, which consists of a stator housing 5 integrated into the housing 2, and a rotary housing 6 rotatably mounted in the bore of the stator housing 5. The outer diameter of the stator jacket 5 corresponds to the outer diameter of the housing 2. The upper end 7 of the stator housing 5 is screwed onto section 8 bearing an internal thread in the housing bore provided with an outside thread having a smaller diameter than housing 2. In the lower end 9 of the stator housing, also provided with an internal thread, a guide housing is threadedly connected. The rotary housing 6 is provided between the forward nose region 11 of the portion 8 and of the nose surface 12, and is mounted thereto in the axial direction. The nose surface 12 and the opposed surface of the rotary housing 6, which cooperates therewith, are provided with a step in order to improve the seal. The housing bores of the rotary housing 6 and of the guiding housing 10 have the same internal diameter. The upper end 13 of the rotary housing 6 is closed by means of a wall and has an outwardly open coupling bore 13 in which the end of a drive shaft 16, shaped as a coupling peg 15, is gripped in a turn-free manner and without play in a radial direction. In this manner, the drive shaft 16 provides the radial mounting for the end 13 of the rotary housing 6. The drive shaft 16 is mounted by two rotary bearings 17, which are provided in a chamber defined by the portion 8 of the housing 2. The drive shaft 16 extends through a bore out of the portion 8 and is sealed in the bore with the help of a sealing ring 18. The end of the rotar housing 6 adjacent the nose surface 10 is provided on its mantel surface with a raised, annular bearing surface which defines a slide bearing with the bored surface of the stator housing.

In the wall of the stator housing 5 there are provided, in symmetrical arrangement, openings 19, which extend as slots in an axial direction. Between the openings 19 are located closed wall portions 20, of which the breadth is significantly larger than the breadth of the openings 19. The end surfaces at the small portion of the openings 19 are sloped in accordance with the circulation direction. In the illustrated position of the rotar housing 6, the openings 19 are likewise constructed as axially extending slots. The openings 21 are separated from one another by closed wall portions 22. The breadth of the openings 21 is somewhat greater than the breadth of the openings 19. Their length

matches the length of the openings 19 such that the end surfaces at the small side of the openings 21 are likewise sloped. The breadth of the wall portion 22 is of a size such that, by rotating the rotary pausing housing through a predetermined angle, the openings 19 are completely closable by the wall portion 22.

The end of the drive shaft 16 which is opposed to the rotary housing 6 is connected by a coupling 23 with the output shaft 24 of a drive train which consists of a reducing drive 25 and a direct current motor 26. To create the signal, the direct current motor 26 changes its current direction, upon which it periodically changes its direction to assume the illustrated flow position or the throttle position, in which the wall portions 22 cover the openings 19 and the wall portions 20 cover the openings 21.

In order to obtain flow-through measurements it is essential to begin with an exact positioning of the measurement device 1 in the drillstring 3. For this, the drillstring encodes an orientation portion 27 in which there is found an inwardly projecting orientation wedge 28. Over the orientation wedge 28 there is provided in the orientation portion 27, through a contraction, a bypass ring 29 with parallel-axis bypass bores 30 and a central take-up bore 32. For the set-up and orientation of the measuring apparatus 1 in the orientation portion 27, the guide housing 10 is used. The guide housing 10 is provided at its lower end with a point 33 having two opposed, sloping, curved wedge surfaces 34 which lead to an axis-parallel slot 35.

The guidance housing 10 is utilized to set up and establish the measurement apparatus 1 in the orientation portion 27. The guidance housing 10 is provided at its lower end with a point 33, having two oppositely sloping, curved wedge surfaces 34 which lead to an axis-parallel slot 35. Close to the slot 35, the guidance housing has two resilient detents 36, which serve to secure the guidance housing 10 in the orientation portion 27. If the measuring apparatus 1 is lowered into the borestring 3, the point 33, after passing the receiving bore 32, comes into contact with the orientation wedge 28, and operates to rotate the measurement apparatus 1 until the orientation wedge 28 can be forced into the slot 35, by which the measuring apparatus 1 is lined up and fixed in the

intended angular orientation in the drill string 3. The measurement apparatus 1 can then be lowered until the guidance housing 10 with its collar 37 rests on the step 31 of the bypass ring 29. Upon reaching this condition, the detents 36 are radially snapped outwardly, whereby with their free ends they grasp the bypass ring 29 from underneath and thereby hold the measurement apparatus 1 securely in its packaging. The detents 36 are arranged as conditional locks such that they can, with the help of a particular pulling force upwardly directed against the measurement apparatus radially inwardly exerted, in order to make it possible to pull the measurement apparatus 1. A sealing ring 38 seals the collar 37 in a receiving bore 32. The annular space 39 extending beyond the bypass ring 29 outwardly of the stator housing 5, in the borestring 3, is widened at its internal diameter and provides a pocket for receiving solid particles which are carried along with the drilling circulation.

For producing an alarm signal, the rotor housing 6 in the described signal producer 4, with the help of the D.C. motor 26, is rotated back and forth on a continuous basis so that it is in constant change, sometimes in throughput condition and sometimes in throttled condition. For a number from eight or more slots only a small rotational angle is required in order that the loading of the seal 18 on the drive shaft 16, and the energy requirement for the motor, both remain small. In the throughput configuration of the rotor housing 6 the circulation required by the borestring 3, on the one hand along the outside of the stator housing 5, and through the bypass bore 30 and the other side through the slots 19, the openings 21 and the bores of the rotor housing 6 and the guidance housing 10 flow downwardly into the bore tailings. If the rotor housing 6 is rotated to the throttle configuration, the stream cross section inside the signal producer 4 is locked, leading to a sudden pressure spike in the drilling stream which immediately advances to the surface and can be caught when this happens. If the rotor housing 6 is returned to the throughput configuration, the circulation stream once again has the entire stream cross section available to it. The pressure again sinks to the previous level, which at the surface can be measured. Utilizing a quick succession of such control movements, the measurement signals based on the measurement apparatus can, as pressure impulses, be sent to the surface by way of the bore circulation.

Claims

1. A drill hole measurement apparatus with a device for transferring measurement data obtained during boring through bore circulation to the surface, with an elongate housing that can bc lowered to a predetermined level, can there be fixed in a defined angular position, and can then be withdrawn out of the drill hole, a hydro-mechanical signal producer provided in the housing with a stator secured with respect to the housing, the foregoing having at least one throughput through which the drilling circulation at an upstream-lying side of the stator is directed to a downstream-lying side of the stator, and a rotor near the stator, the rotor bcing rotatably mounted in the housing about its longitudinal axis, at least one throughgoing opening corresponding to the throughput in the stator, and which can take either a throughput configuration, in which the drilling circulation can pass the throughput and the therewith aligned opening, or can be rotated to a throttled configuration in which a closed portion of the rotor throttles the flow through the throughput, and a motor through which the rotor, in accordance with the characteristic measurement data to be transferred, at controlled intervals repeatedly moves from the throughput configuration to the throttle configuration and from the latter configuration back to the throughput configuration, to create in the drilling circulation a coded series of positive pressure impulses which correspond to the signals, characterized in that, the signal provider (4) is located at the lower end of thc housing (2), whereby the stator is made of a cylindrical stator housing open at its lower end, and the rotor is made of a cylindrical rotor housing (6) located in the bore (5) and is coaxial with the latter and open at the lower cnd, and the stator housing and the rotor housing each have a pair of diametrically arranged slots extending in the longitudinal direction which provide the throughput/opening (19/21), and through which, in the throughput configuration, the bore circulation directed against the outer side of the stator housing (5) flows into the bore of the rotor housing (6), and the latter can be released downwardly through the open ends of the rotor housing (6) and the stator housing (5).

2. A drilling hole measuring apparatus as claimed in claim 1, characterized in that, at the lower end of the stator housing (5) there is attached a guide housing which has on its surface a recess cooperating with an orientation wedge (28) of the drill-string (3); and a

releasable detent (36) for arresting the drill string (3) , and an openable detent 36 for arresting the drill-string (3), such that the bore of the guide housing (10) closes immediately on the bore of the rotor housing (6), so that an unhindered outflow from the signal giver is assured.

3. drilling hole measuring apparatus according to one of claims 1 or 2, characterized in that, the rotor housing (6) with its open ends is mounted directly in the stator housing (5) and with its closed ends (13) mounted to a drive shaft (16) which is secured to the rotor housing (6) through a plug-in coupling in a manner to resist mutual rotation.

4. A drilling hole measuring apparatus according to one of the previous claims, characterized in that, it results in the mounting of the rotor housing (6) in the axial direction on the nose surfaces (11, 12) of the building surfaces (8, 10) which close on the stator housing (5).

5. A drilling hole measuring apparatus according to one of the previous claims, characterized in that, the stator housing (5) has an internal thread on both ends of the housing bore, and with one end on one of the housing portions (8) forming part of the drive shaft, and with the other end is screwed onto the end of the guide housing (10) that is provided with an external thread.

6. A drilling hole measuring apparatus according to one of the previous claims, characterized in that, the slots in the rotor housing (6) are wider than the slots in the stator (5).

7. A drilling hole measuring apparatus according to one of the previous claims, characterized in that, the width of the slots of the stator housing (5) and of the rotor housing (6) increases in the direction of flow.

8. A drilling hole measuring apparatus according to one of the previous claims, characterized in that, an annular space (39) is formed in the drill string (3), which extends at least as far as the lower end of the stator housing (5).